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ABSTRACT

Various aspects of iconic memory have been studied in the past. Two tachistoscopic experiments were conducted to examine how legibility of a stimulus affects a subject's ability to recall brief visual presentation. The studies used letter arrays set in four different typefaces (Helvetica, Cooper Black Outline, Electronic, Old English). In the first experiment, four female subjects, using whole report procedure, named letters seen in a display of four rows of four letters. The set was repeated once with arrows preceding and a second set with arrows following the display to replicate Sperling's (1960) partial report technique. A one-way analysis of variance showed a significant difference between arrows preceding or following display. In the second experiment, the four typefaces were used to compose displays of three rows of three letters each. Slides were tachistoscopically projected to two male and two female subjects. Subjects were shown 10 slides of each of the four alphabets. Results indicated that typeface significantly affected the number of correct responses. Typeface appeared to affect the subject's ability to process the icon. While typeface was found to be a significant factor, a comparison of the means indicated that the greatest difference in legibility was between Helvetica and Old English typefaces. Results of this experiment are similar to a very early study by Tinker (1925) who found Old Roman typeface, or one made up of sharp angles and straight lines, produced the maximum legibility. (Author/NB)

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Effect of Typeface on Iconic Storage Capacity

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Abstract

A tachistoscopic experiment using letter displays set in four different typefaces was conducted at California State University, Los Angeles. Four subjects, using whole report procedure, named letters seen in display of four rows of four letters. Set was repeated once with arrows proceeding and a second set with arrows following display to replicate Sperling's (1960) partial report technique. A one-way analysis of variance showed a significant difference $F(1,2) = 59.44$ $p < .01$ between arrows preceeding or following display. A second experimnet used displays of three rows of three letters. Four sets of displays were used, each set in a different typeface. A repeated measures analysis of variance $F(3,12) = 17.51 < .01$ showed typeface to be a significant factor in correctly perceiving letters from brief visual displays.

Effect of Typeface on Iconic Storage Capacity

How are brief visual presentations processed? In span of attention experiments, subjects are often asked to report or name items seen in brief visual displays. While visual presentations of 50-500 ms seldom occur outside the laboratory setting, these experiments have resulted in the discovery of complex human information processing capabilities.

In a series of experiments, Sperling (1960) used brief visual presentations of letters to determine the amount of stored information. His subjects reported that more was seen than could be remembered. This led Sperling to theorize about the specific limit on the amount of information that can be reported by subjects. He found subjects were unable to give a whole report when the number of letters in the stimulus exceeded the memory span. The whole report contained between four and five correct items when nine letters were presented. Subjects correctly reported an equal number of items that were in the stimulus when this number was less than four. When the stimulus contained five or more symbols, subjects could only report 4.5 items correctly (Sperling, 1963). The processing limit has been shown to exist in various sensory modalities and according to Miller (1956), it is equal to seven, plus or minus two.

In the classical whole report experiment, subjects were shown a visual display of letters and asked to report total number of items seen (Averbach & Sperling, 1961). The number correctly reported, 4.5 when stimulus contained five items, was not affected when exposure time was varied from 15 to 500ms (Sperling, 1960).

Sperling next used a partial report experiment in order to determine the amount of information subjects had available before the report. Subjects were shown a stimulus initially consisting of two or three lines. A tone followed the visual presentation and indicated which row was to to reported. Sperling's subjects did not know which row would be signaled and the maximum number of items that could be reported fell within subject's immediate memory span. Results showed that for all stimuli and for all subjects, the amount of available information was greater in the partial report than in the full report (Sperling, 1960). Subjects reported an average of 9.1 letters out of 12, compared with 4.5 items using the whole report method (Averbach & Sperling, 1961).

When exposure of the display was reduced to 5 ms, contrast in the stimulus was reduced, but this did not affect the number of items correctly reported. However, delaying the tone for more than one second caused percentage of correct responses to drop from 76 to 36 % (Sperling, 1963).

As the length of the tone delay approached one second, the number of errors was found to increase until the number of items reported correctly was equal to the number correct using the whole report technique (Sperling, 1963). The period of time following the presentation was found to be critical to the report and could not be longer than one second (Sperling, 1960).

The phenomenon of holding the visual image until the time for the report has been called iconic memory by Neisser (1967). Iconic storage is the brief storage of the visual image and differs from short-term memory. The visual image is held in its literal form in iconic memory until an asymptote point between 200 and 100 ms after stimulus presentation (Dick, 1974). Iconic memory is related to saccadic eye movements. Subjects were shown to have 250 ms between eye movements to transfer information to a more durable storage system (Sakitt, 1976). Processing was found to have ended by the time eye movement occurred (Dick, 1974). However, when eye movement did occur, 400 to 500 ms after the display, subjects shifted the display in the direction of the eye movement but the icon was found not to be erased. (Doerflein & Dick, 1974 as cited in Dick, 1974). Townsend (1972) varied the duration of the cue and also found long cues of 900 ms increased errors while brief cues enabled the subject to make use of iconic memory.

Various aspects of iconic memory have been studied in an effort to discover why the partial report is superior to the whole report. A physiological explanation (Sakitt, 1976) speculates that the icon is a rod rather than cone phenomenon and storage is in different systems. Storage of the icon within photoreceptors was offered as an explanation to the superiority of partial over whole reports. Dick (1967,1969, as cited in Townsend, 1972) found that the kind of information processed caused different rates of iconic decay.

In order to study the amount of information available to an observer two experiments were conducted using whole report and partial report procedure. Lettered stimuli were used in both cases because these were used by Sperling and other experimenters and also because different typefaces were studied. An arrow was used instead of a tone in both experiments replicating a study by Averbach and Coriell (1961) which used a bar marker as a probe. Although reaction time was longer for the bar marker than the tone marker, results paralleled Sperling's findings.

Experiment 1

Method

Subjects. Four female students aged between 23 and 39, students in an experimental psychology class at California State University, Los Angeles, served as subjects for the experiment and were not paid.

Apparatus. White self-adhesive Helvetica Signmat letters 1.5 cm wide and 2.54 cm high were randomly arranged on a white outlined grid of 16 squares on black poster board. Random displays of 16 letters containing only consonants were photographed on Kodak Ektachrome ASA 200 slide film. An arrow was photographed against the blank grid. Arrow pointed to each row or column or was in other words, in eight different positions. Slides were projected from a Kodak Ektagraphic projector mounted on a table 125 cm high and placed 308 cm from a screen. A Gebrands tachistoscope with a high speed digital timer was set at 500 ms shutter speed for letters, 500 ms delay and 500 ms for arrow slides which were randomly arranged in a second projector.

Procedure. The experiment was conducted in a partially lit room with light controlled by a dimer. Subjects were seated in front of the two projectors. Experimenter instructed subjects to report in first trial of 20 slides, letters seen. Presentations were preceeded by experimenter saying, "Ready, set, go" before each slide. Subjects recorded their own responses. Series was repeated using a partial report technique. In one set, arrow preceeded letter slide and second set arrow followed. Subjects were instructed to report letters in column or row indicated by arrow.

Results

Mean for the whole report was 3.84 letters. When an arrow preceeded display, mean number of letters named was 3.53. When arrows followed display, mean number of correct letters was .75. When arrows followed letters, subjects did not know either which of four rows would be selected or four columns called for in report. Performance for partial report was determined (Sperling, 1960) to find number of letters stored and available for readout. Mean number of correct letters was multiplied by eight possible column or row positions for arrow resulting in mean of six letters for partial report. A one-way analysis of variance showed a significant difference $F(1,2) = 59.44$ $p < .01$ between arrows preceeding or following display.

Discussion

While it was found that six letters were named using the partial report, and this was more than the 3.84 for the whole report, results could have been better had the probe been displayed quickly after the letter display. A long probe was found by Townsend (1972) not to mask the icon but to degrade it. Conrad (1960) also found a delay of one second to be damaging to the message trace. In addition, grid lines may have added confusing information. Averbach and Coriell (1961) found that reading out was disturbed when too much data was put in and added that 16 letter displays would demonstrate this effect.

Brown (1960) found that recall was higher when instructions were given before presentations because when the marker follows the subject has to attend to it. In this experiment, means of 3.84 for whole report and 3.53 for partial when arrow preceeded display contrasted with .75 when arrow followed display, demonstrate this effect. Estes (1972) found that pretrial information concerning positions or other properties of stimuli does not affect processing but does affect readout. Averbach and Coriell (1961) found when arrows preceeded the array, performance only reached a maximum level of 65 to 80 % correct because some letters were not legible in the context of the display.

Because the time before the marker was shown was so long, there were probably eye movements and shifts and transfer of information and decay of the icon.

Experiment 2

How does the legibility of the stimulus affect the subject's ability to give an accurate report? As graphic artists and advertisers know, typeface can convey various moods and carry an emotional atmosphere (Kastl & Child, 1968; Poffenberger & Franken, 1935). Tinker (1925) compared eight different typefaces and found Roman to be more legible than German. Burtt and Basch (1923), found differences in typeface to be more marked with capitals than lowercase letters. In addition, they found Cheltetenham to be more

legible than Baskerville and Bodoni. Maximum legibility was found with Roman caps made up of straight lines and sharp angles. Confusion was found by Tinker (1925) to be associated with hairlines and whitespace within an outline. Narrow letters and familar letters such as a and e also were found to be confusing. Crosland (1928) found apprehension affected by shape of letters. The largest difference was between vertical letters, such as m, u, r, i, h, j, and curved letters such as g b, d, and p. Serifed letters such as l, h, y, f, b, j, p, and t were found to be more legible than unserifed letters such as r, a, x, e, and s.

In reaction time experiments, Mecacci and Salamasco (1984) found processing time for vowels faster than for consonants. Printed letters, both vowels and consonants were processed faster than script typefaces (Salmaso & Umità, 1982, as cited in Mecacci & Salamaso, 1984). In assembly tasks, Haber, Standing, and Boss (1970) found typeface and size of print not to be a factor. Using a recognition task, their subjects were able to perceive a capital A and a subsequent lowercase a in italic in a different part of the visual field.

Spacing was a legibility factor noted by Crosland (1928). Although highly criticized (Hartley & Room, 1983), Sir Cyril Burt noted in a 1960 study that legibility and accuracy improves when material is set in a typeface

the reader finds aesethically pleasing. In tachistoscopic experiments, Aveling (1932) found confusion in order, inversion errors, separation of parts and agglutination of letters including vowels.

To study the effect of typeface on iconic memory, four typefaces, Helvetica, Cooper Black Outline, Electronic, and Old English were used as display letters. It was hypothesized that typeface would affect number of errors and affect correct responses to brief visual presentations consisting of lettered displays.

Method

Subjects. Two male and two female students in an experimental psychology class at California State University, Los Angeles, served as subjects for the experiment.

Apparatus. Four alphabets were used and all letters were 48 point type black letters. Letters were mounted on a white background without a grid, and photographed with Kodak Ektachrome ASA 200 slide film. Four alphabets were used: Helvetica, Formatt No. 5529; Cooper Black Outline, fasttype C 63-48; Electronic, Formatt No. 5842; and Old English, Chartpak 2848c. Letters were selected for each display without replacement from a random number's table. Three rows containing three letters were used in each display.

Insert figures 1-4 about here

Ten slides of each typeface and 20 arrow slides, indicating top, middle or bottom were shown.from Kodak projector. Arrows were projected from a second projector. A Gebrands tachistoscope with a high speed digital timer was set so left shutter speed was 500 ms, interval 10ms, and right shutter, 500 ms.

Procedure. The experiment was conducted in a dark room with light adjusted by a dimer. Subjects were seated in front of projectors. Experimenter showed subjects samples of the typefaces that were to be projected. Ten slides were shown from each of the four alphabets. Subjects were asked to first give a whole report and name letters seen. A second set was run using a partial report technique. Subjects were shown ten slides of each typeface and each slide was followed by an arrow slide that indicated row of letters to be reported. Subjects were asked to write down all letters seen in the specified row. Arrow slides were randomly arranged to indicate row to be reported.

Results

Scores for each alphabet indicated a difference in means for each typeface when the whole report was called for. Means were Helvetica, 4.4 letters reported; Outline, 3.03; Electronic, 2.88; and Old English, 1.68. Subjects reported 48.89% of display correctly when it was set in Helvetica as compared to 18,67% for Old English. There was a large difference in errors between the four typefaces. Mean number of errors were: Helvetica, 1.29; Outline, 2.83; Electronic, 3.33; and Old English, 10.16.

A repeated measures analysis of variance $F(3,12) = 17.5 < .01$ indicated that typeface significantly affected the percentage of correct responses. The overall mean for the whole report procedure was 3.0 rather than 4.5 reported by Sperling (1960).

Means of letters reported during the partial report part of the experiment, when arrows followed letters, were multiplied by three to calculate the number of available letters. Means for each typeface were as follows: Helvetica, 5.7; Outline, 3.08; Electronic 3.08 and Old English, 1.5. While the number of available letters was more than the number for the whole report, the means for Helvetica, Outline, and Electronic were less than Sperling found. An analysis of variance, using means of available letters proved insignificant, $F(1, 16) = .51 > .01$.

Discussion

The findings show that typeface affects subject's ability to process the icon. While the analysis of variance indicated that typeface was a significant factor, comparing the means for both whole and partial report demonstrates that the largest difference in legibility was between Helvetica and Old English, while Outline and Electronic produced similar means and in the case of partial report, their means were identical. The large amount of information, lines, hairlines, spaces in the Old English typeface may have required a longer scanning time than the one letter per 10 ms Sperling (1963)

suggests. The complexity of the Old English typeface may have also produced unnecessary eye movement, since researchers have suggested that shifts may occur when stimulus is presented for longer than 100 ms (Hunter & Sigler, 1939). In studying letter differentiation, (Poulton, 1965) research has shown that modern styles are read faster than old styles. Results of this experiment are similar to Tinker's (1925) finding that Old Roman typeface, or one made up of sharp angles and straight lines produced maximum legibility. If typeface was not a factor, then means and errors would have been equal for all typefaces. Helvetica is so highly regarded as being legible that it has become almost a universal alphabet and is used on signs all over the world. While few signs or books are currently printed in Old English, Electroniclike type is often used on equipment and signs.

General Discussion

The results of both experiments indicate that it was not possible to obtain similar superiority with the partial report that was found by Sperling (1960). There are several variables that could account for the discrepancy. Sakitt (1976) found that different experimenters may obtain different results due to a variation in luminescence between tachistoscopes.

In the first experiment, 16 letters and 8 arrow positions plus grid lines made the icon difficult to process and store. The delay of exposure time also contributed to the weak scores for the partial report part of the experiment since most theorists agree that decay reaches a maximum point at 1000ms (Averbach & Sperling, 1961). It was also found by Averbach and Sperling that the rise of information available for subjects began with the stimulus presentation with decay of the icon occurring rapidly thereafter. They found that subjects were only able to hold information for a maximum of five seconds. It is possible that the time it took subjects to report and write down letters took longer than five seconds. Subjects remarked that they began to lose the image when they began to write down letters. While Sperling did find readout to be extremely rapid, writing may slow down response and cause rapid decay. In addition, the writing of a letter on a piece of paper causes the subject to use different processes. This translation component deserves further study.

A study of eye movements could perhaps show if subjects fixated on particualr letters according to their complexity. Because Old English letters contain many parts and separations, it may have been necessary for the eye to circle some components of these complex letters instead of seeing the whole array at once.

Sperling (1960) found an improvement in one subject from 2.9 to 5.8 letters and this high score raised the means in his sample. He also reported in the same experiment that one subject was given 150 trials to try and raise an initial score. A subject in my first experiment was shown to see many more letters per display than the other three subjects. Since individual differences seem to be a factor, a study could be conducted to find out if this difference held for different kinds of icons. In addition, Sperling used experienced subjects who were trained in tachistoscopic experiments. The subjects used in this set of two experiments were untrained but with further practice, performance could have improved.

Technical limitations may have also contributed to poor results. Higher contrast between letters and background, higher luminescence, and photographing of displays so that all are uniform could possibly be tried in future experiments. Use of tones instead of letters could also be attempted. Finally, future research could be done with words set in different typefaces to judge number of words that can be stored as compared to letters.

The study of iconic memory reveals only the surface of what must be a complex human processing capability.

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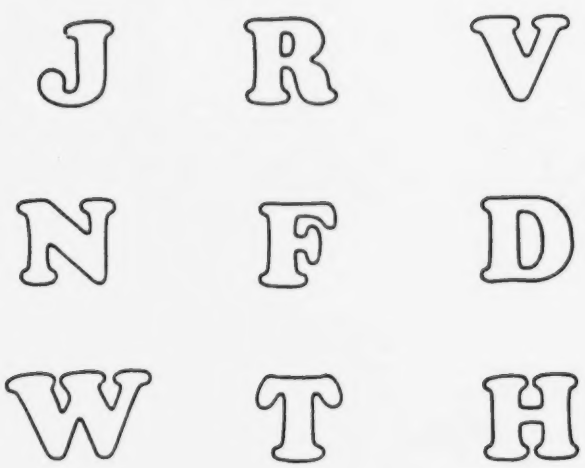
Figure 1

Figure 2



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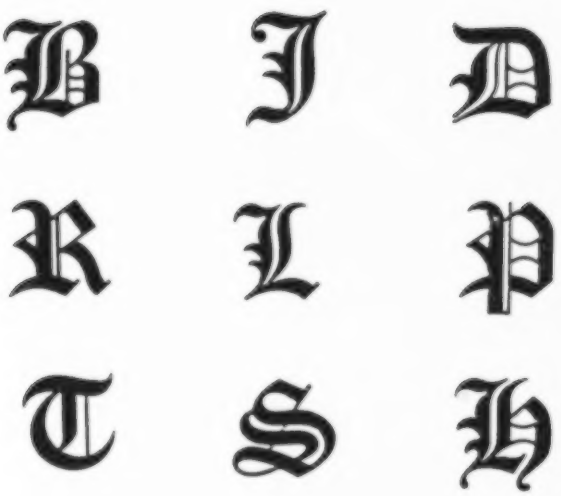

Figure Captions

Figure 1. Helvetica display.

Figure 2. Cooper Black Outline display.

Figure 3. Electronic display.

Figure 4. Old English display.